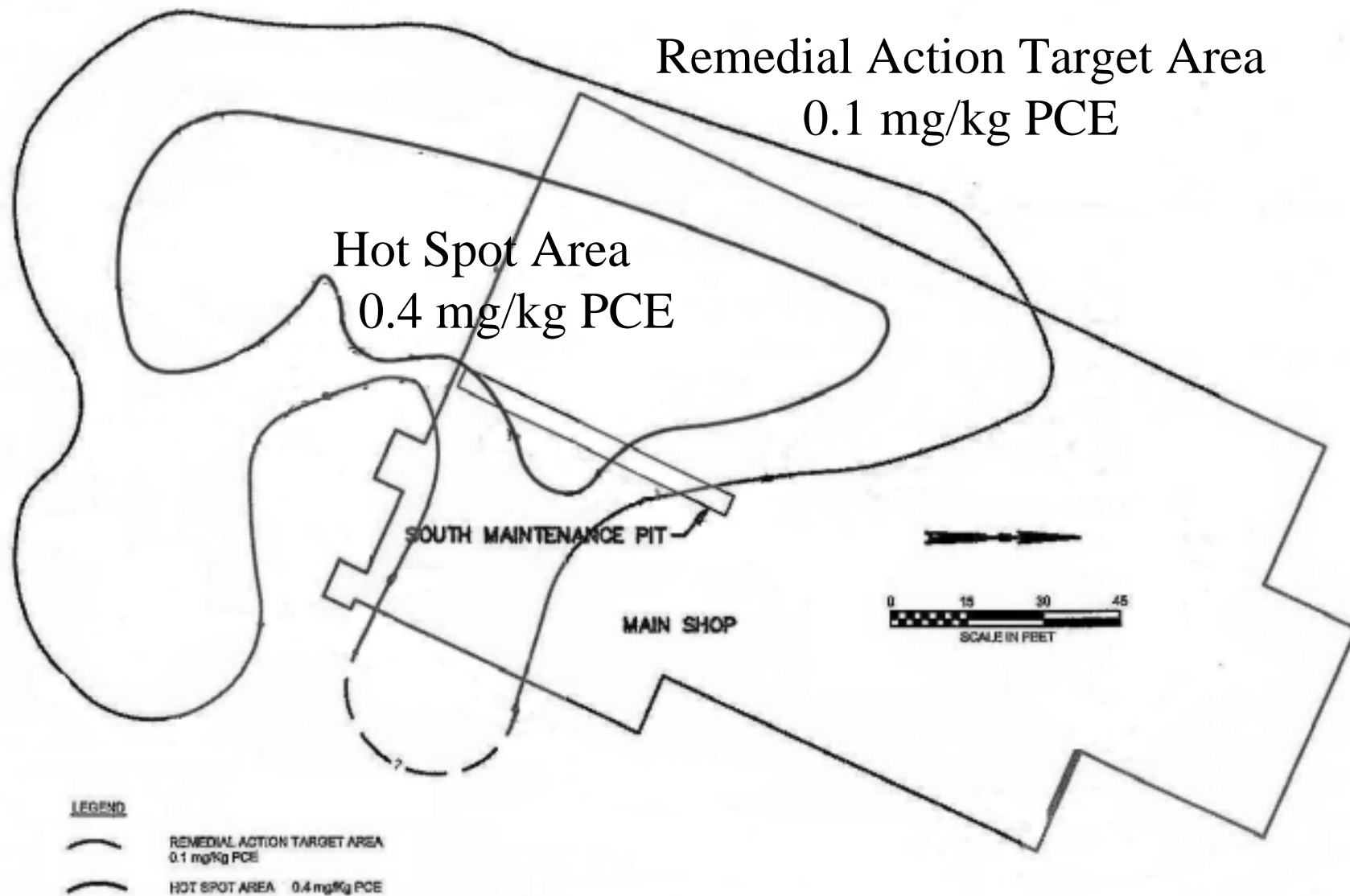


Shallow Hydrofracturing to Enhance Solvent Recovery

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CH2M Hill*

*John P. Gross, Glen M. Wyatt
Weyerhaeuser Company*



Main Shop

Perched Zone



10 ft bgs

$K = 0.07 \text{ ft/day}$

Aquitard

$K = 0.5 \text{ ft/day}$

20 ft bgs

Aquifer

$K = 8 \text{ ft/day}$

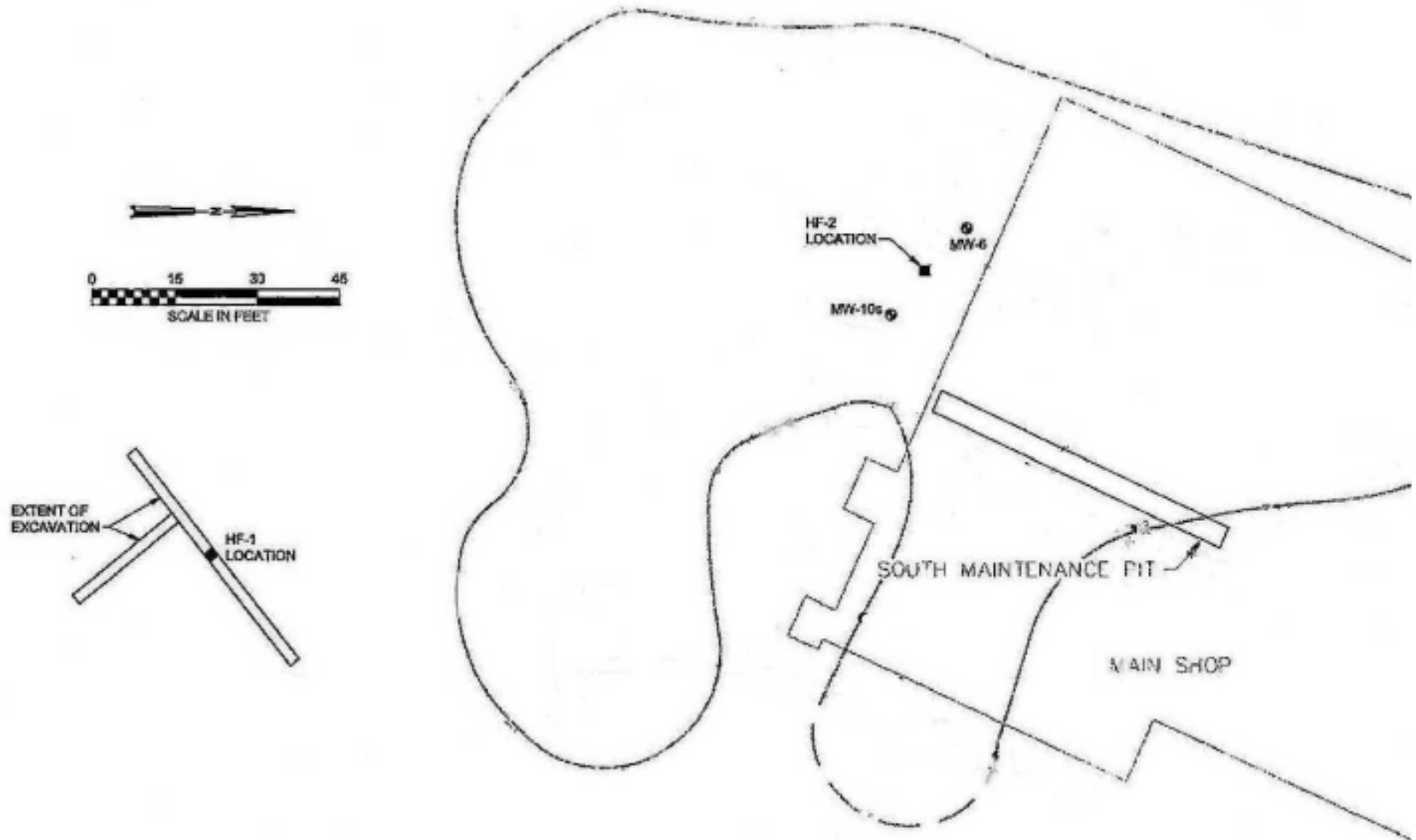


Groundwater Flow Direction

Aquitard Remediation Using Hydrofracturing and Vacuum-Enhanced Extraction

- Phased approach
 - April 2001 - Hydrofracturing Pilot Study
 - October 2001 - Full Scale Hydrofracturing
 - April 2002 - Interim Aquitard Extraction System
 - April 2003 - Full Scale Aquitard Extraction System

Hydrofracture Pilot Study



Drill Rig at HF-1



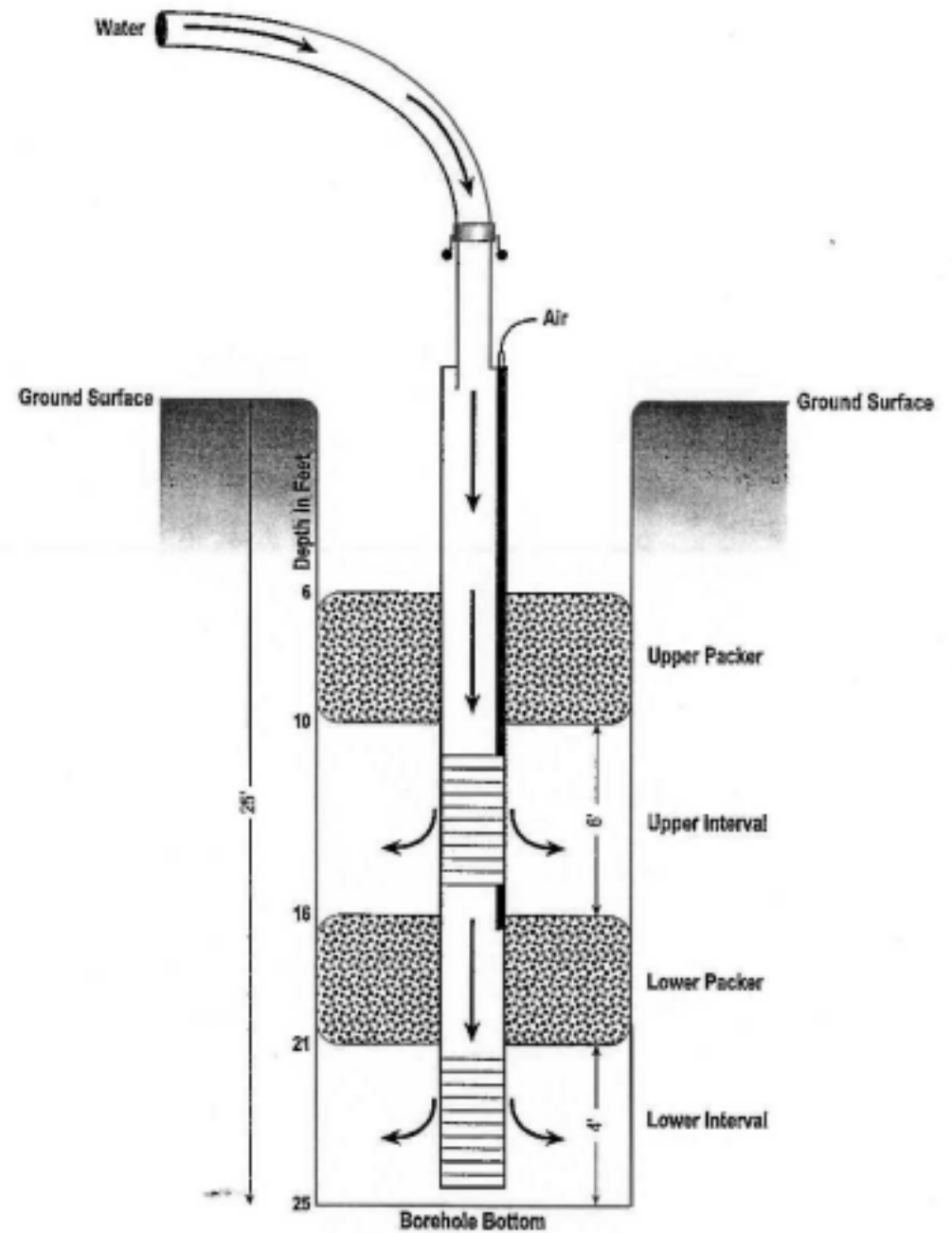
Open Borehole at HF-1





Setting Double Packer in HF-1

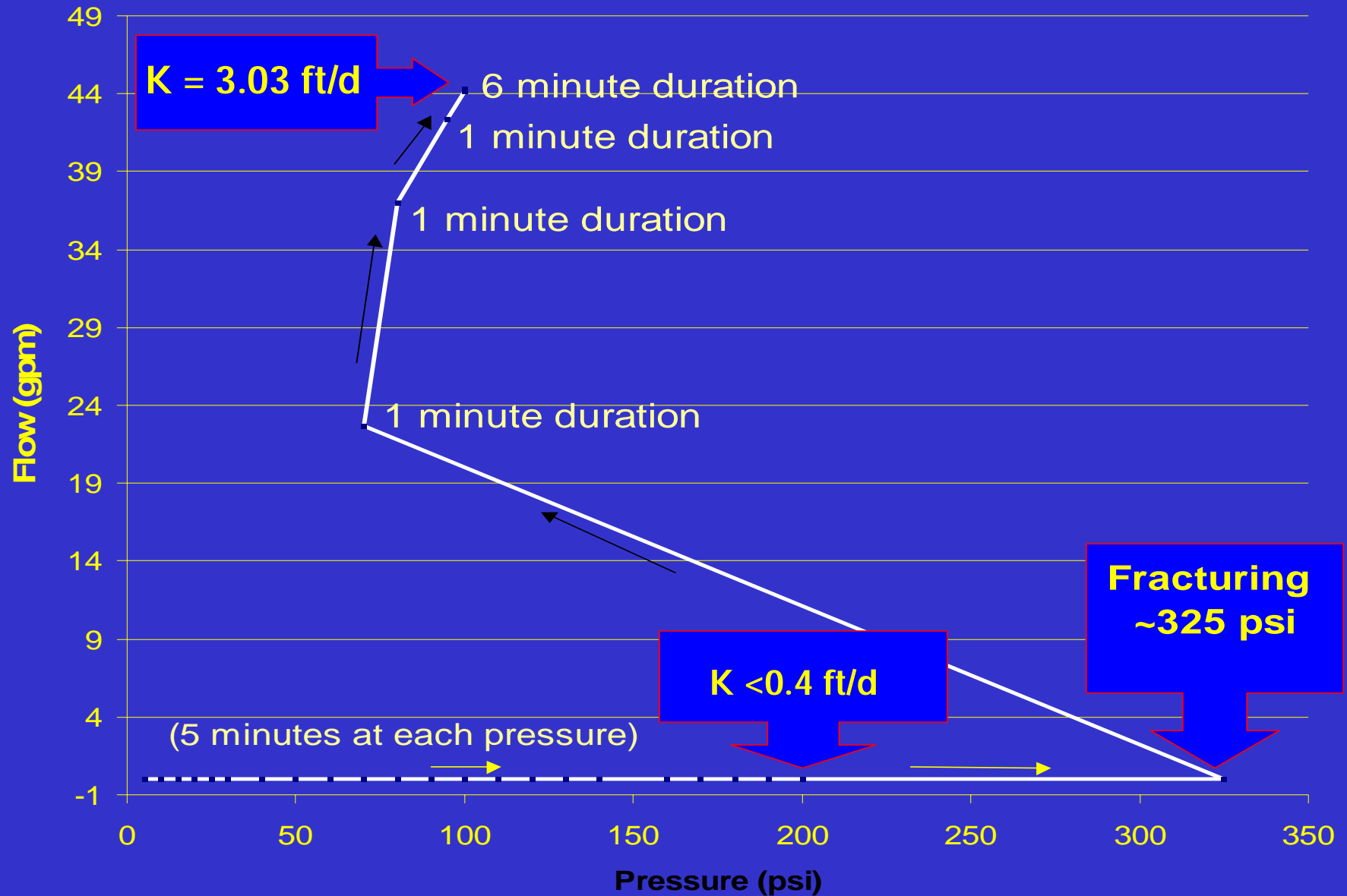
Double-Packer Setup



Injecting Rhodamine
Dye in HF-1



HF-1 Lower Interval



Surface Cracks From
Hydrofracturing HF-1
Lower Interval





Dyed water observed bubbling to surface 12 to 24 feet from
HF-1



Trench Excavation

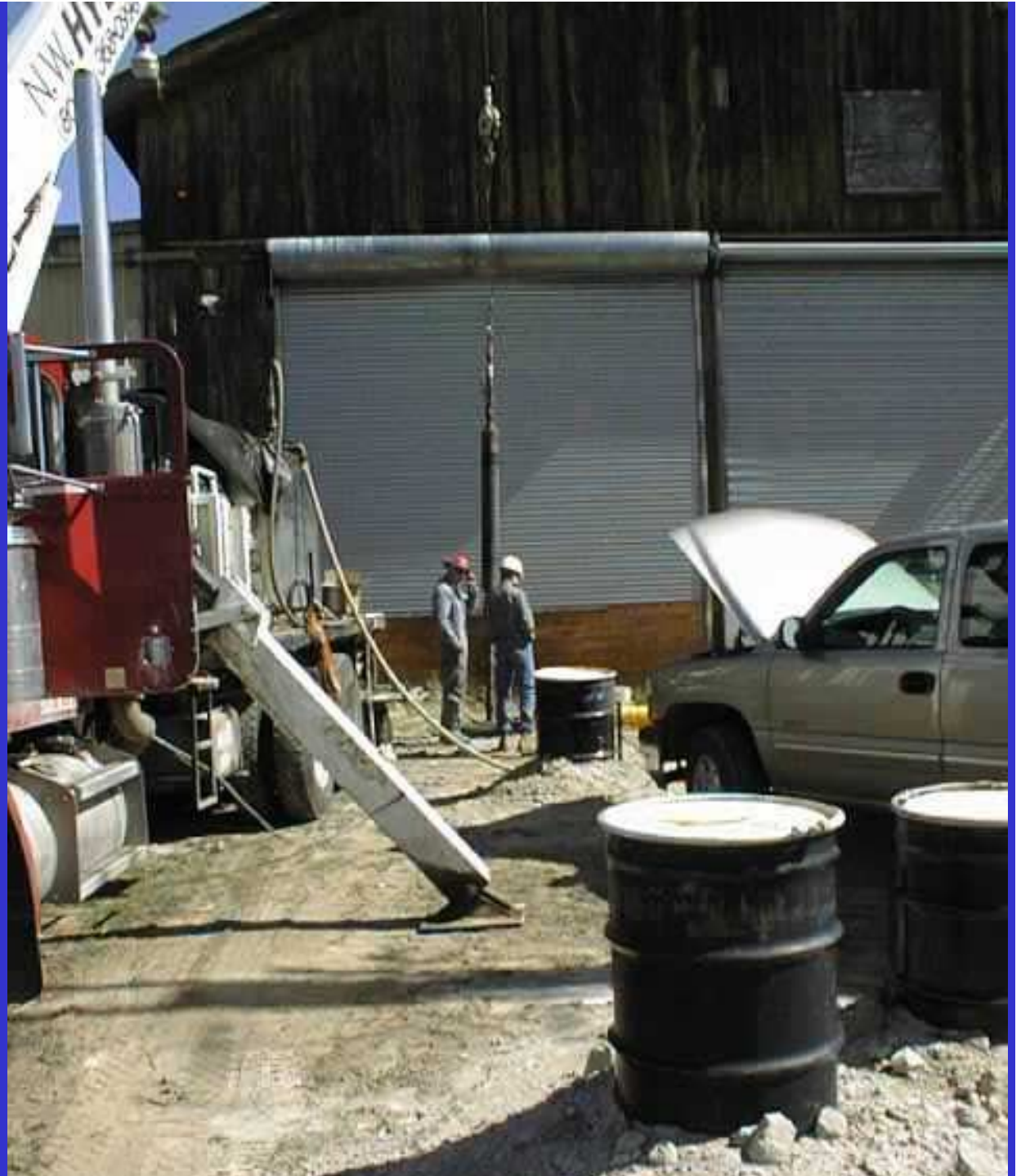
Subsurface Fracture



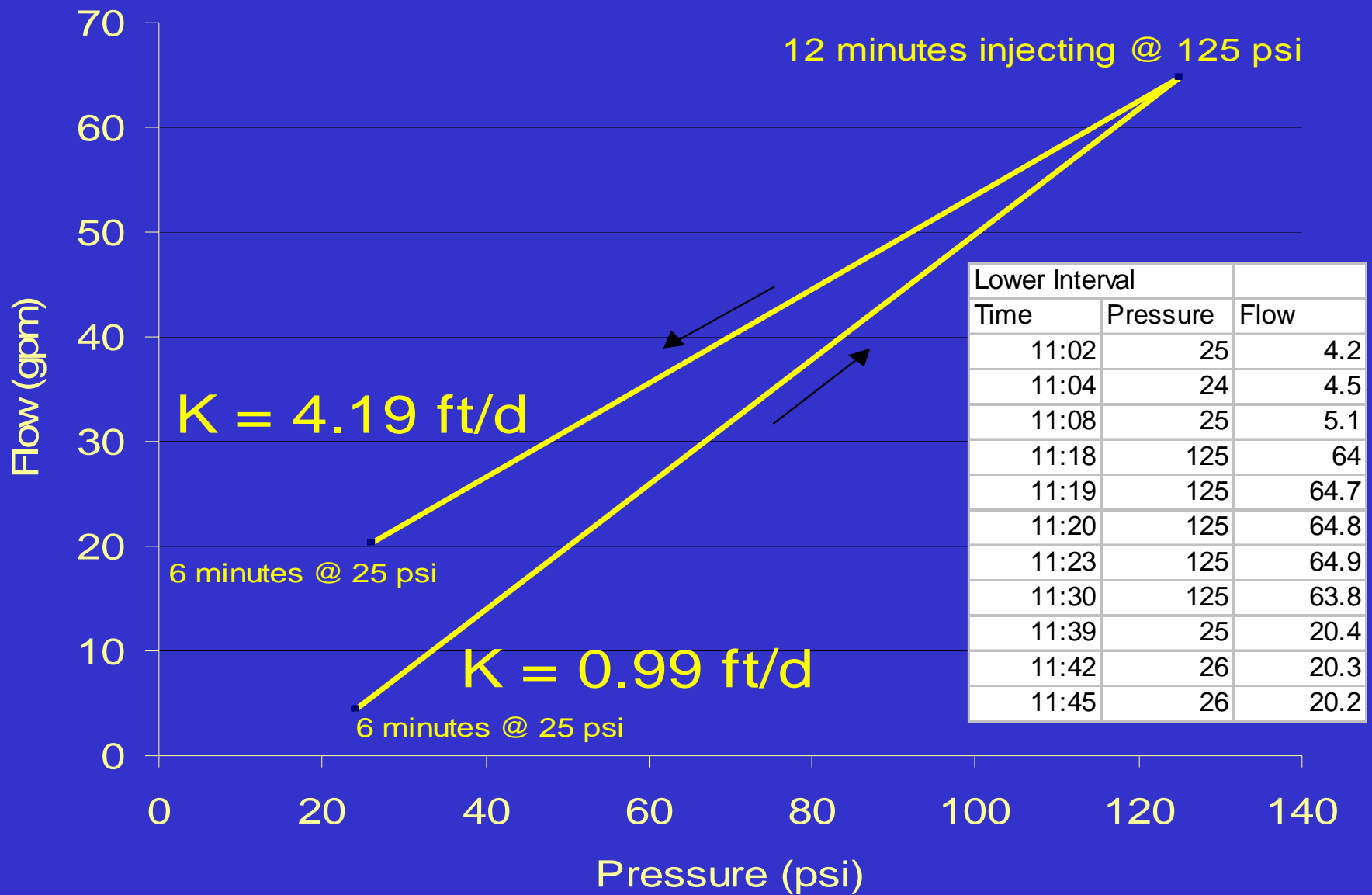
Drilling HF-2 Borehole



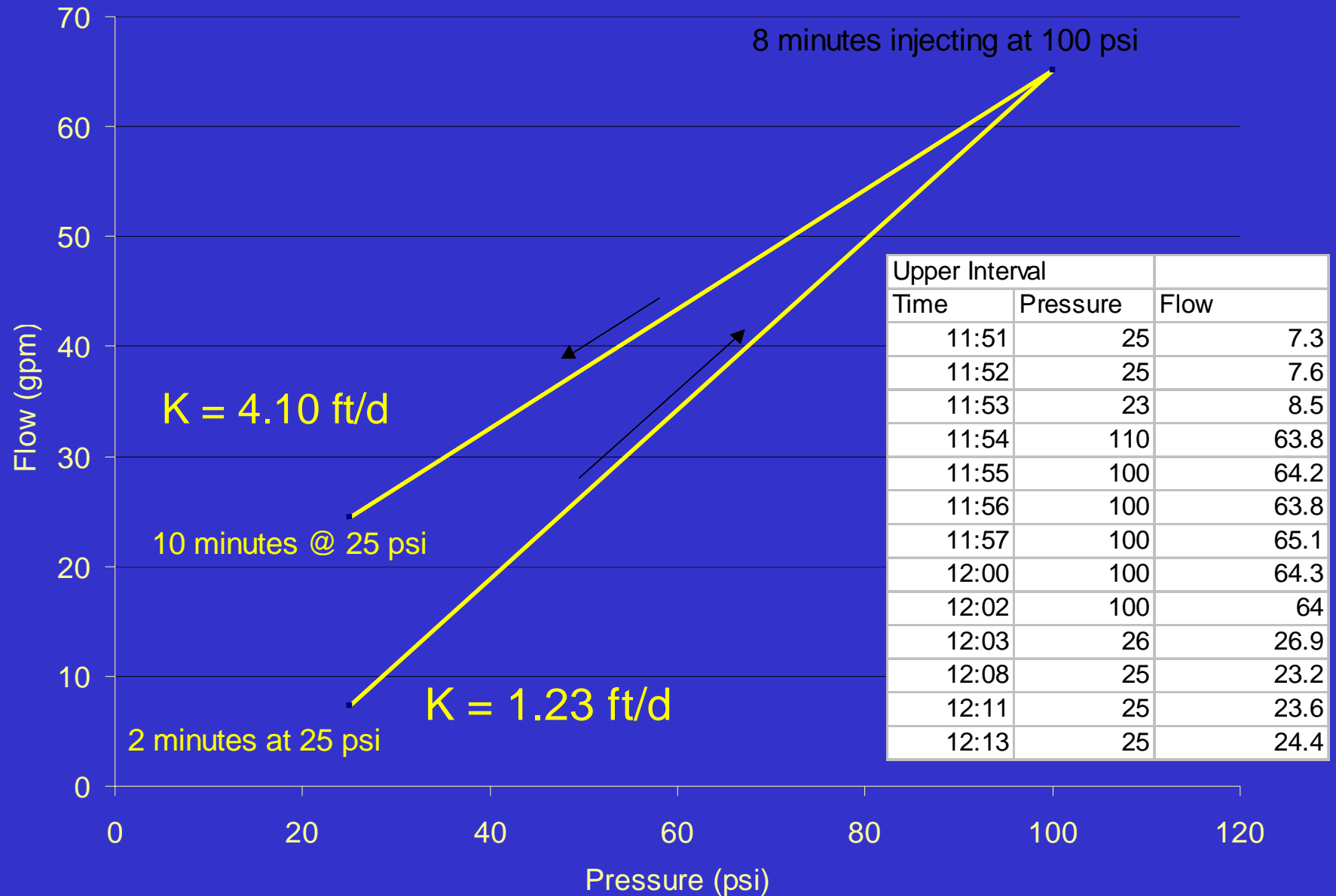
Installing Packer in HF-2 Borehole



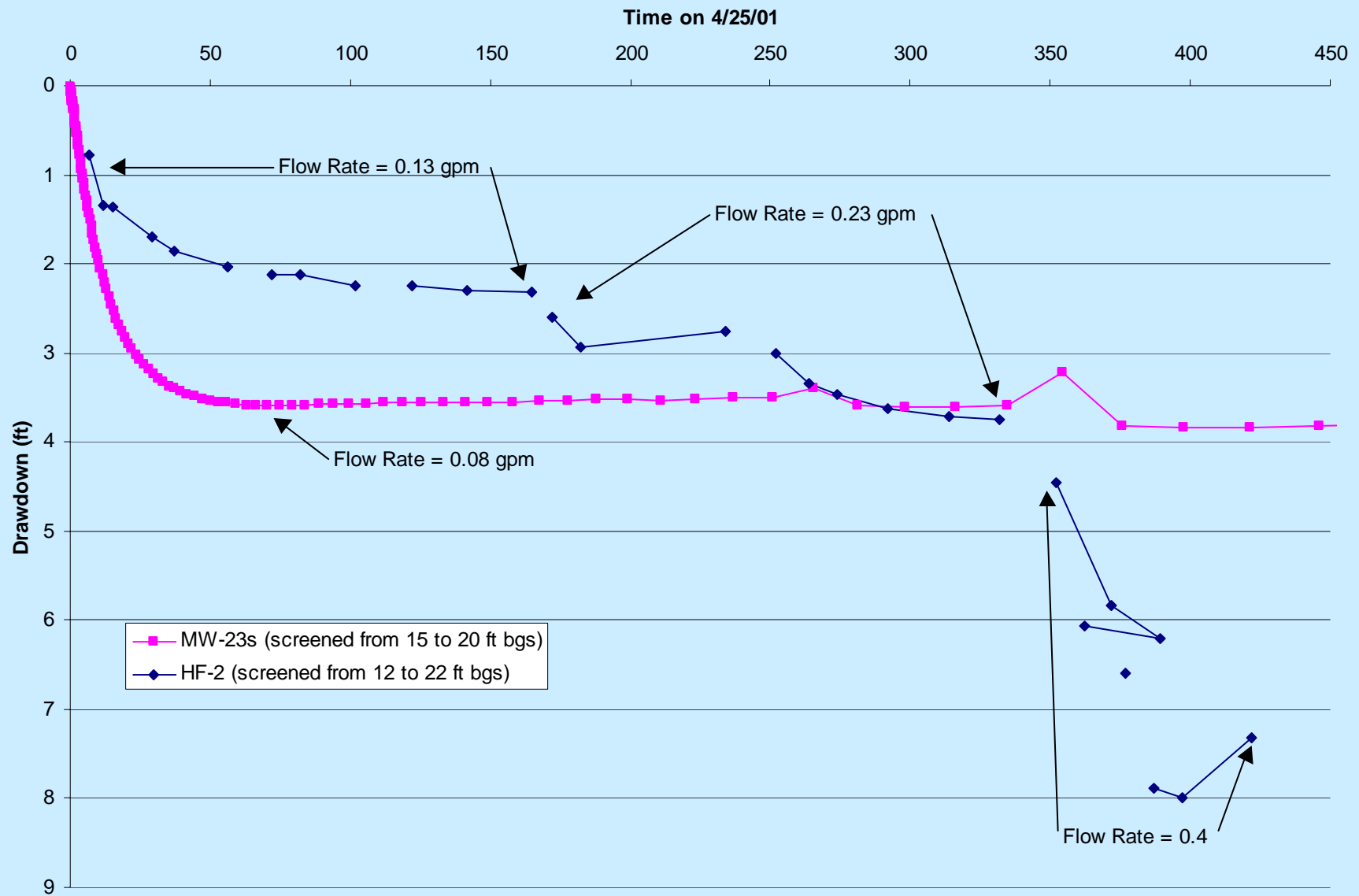
HF-2 Lower Interval



HF-2 Upper Interval



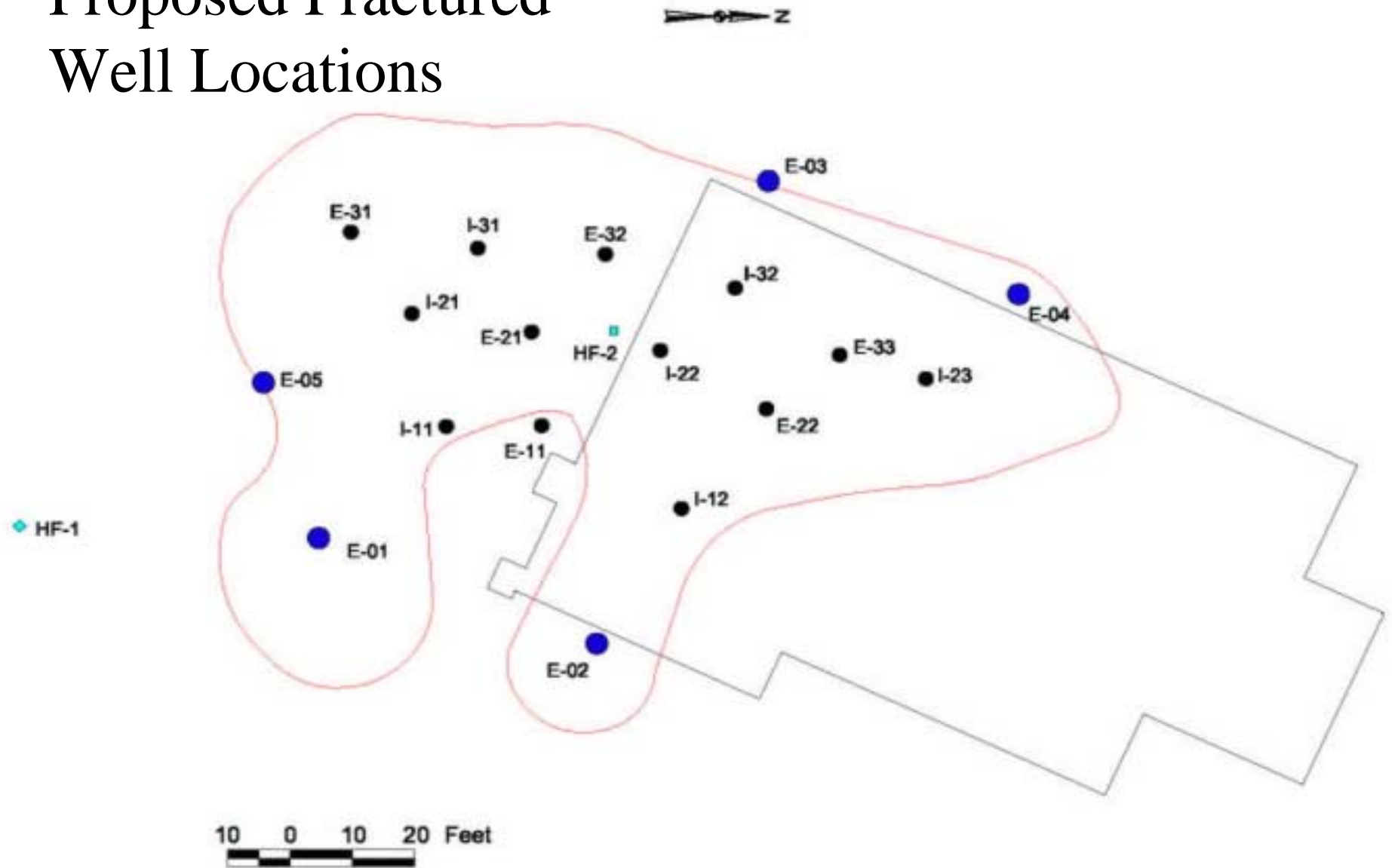
Well Yield Comparison

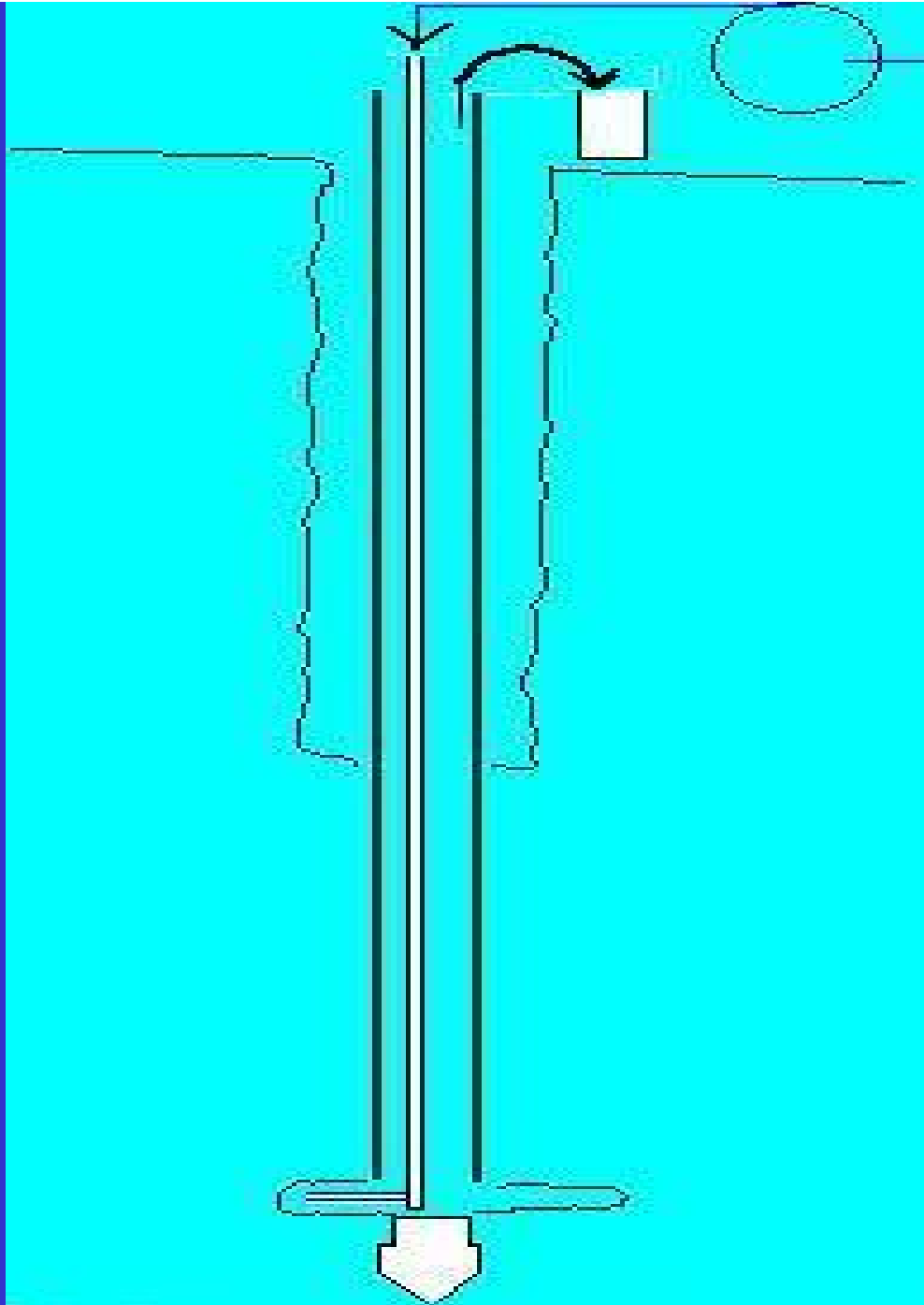


Pilot Test Conclusions

- Based on the Flow vs Pressure Plots, hydrofracturing looked promising
- Flow rate testing results created uncertainty concerning the long-term effectiveness of the fractures
- Decided that propanol was required for full scale application

Proposed Fractured Well Locations





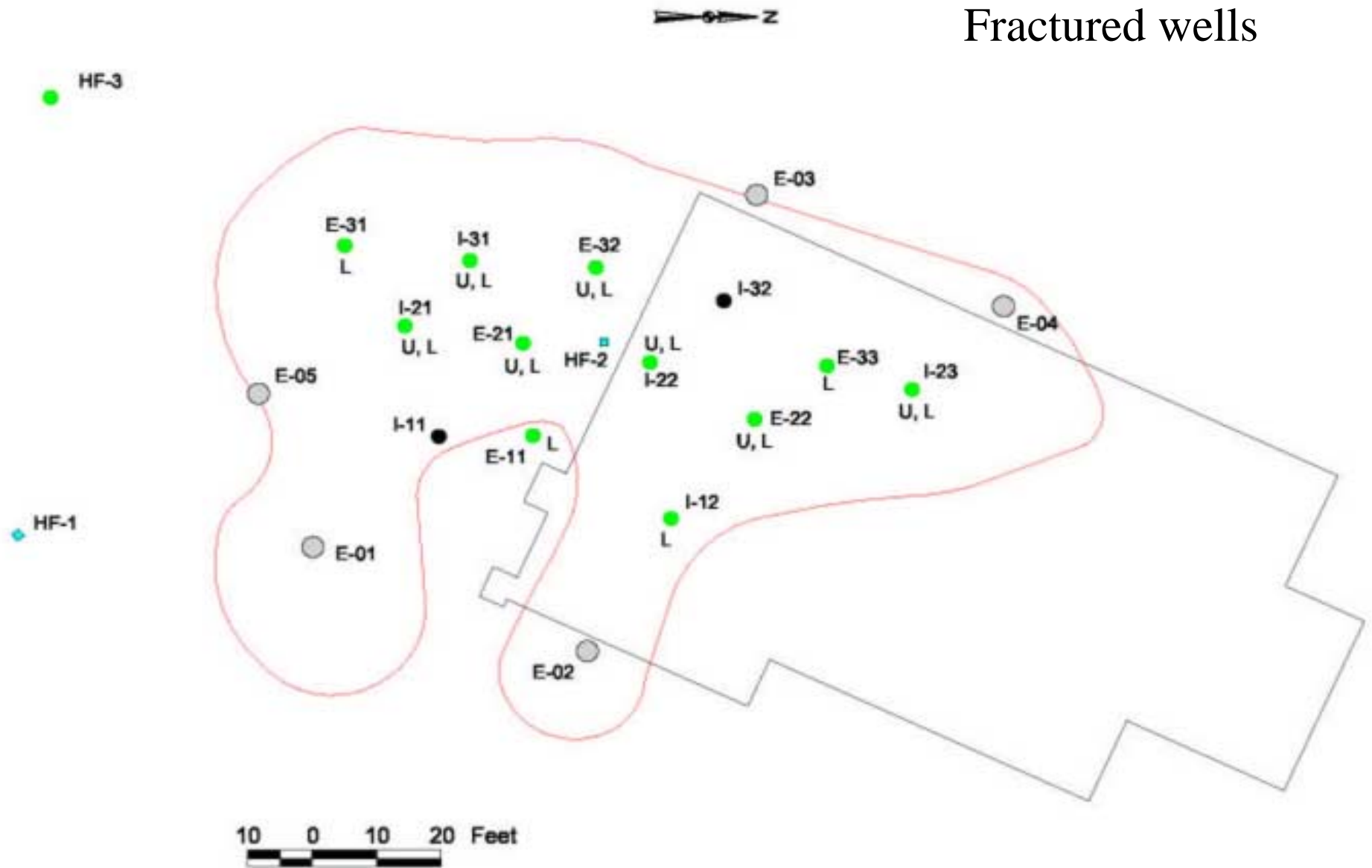
Notching
to induce
horizontal
fracturing

Propant - Mixture of Guar Gel and Sand

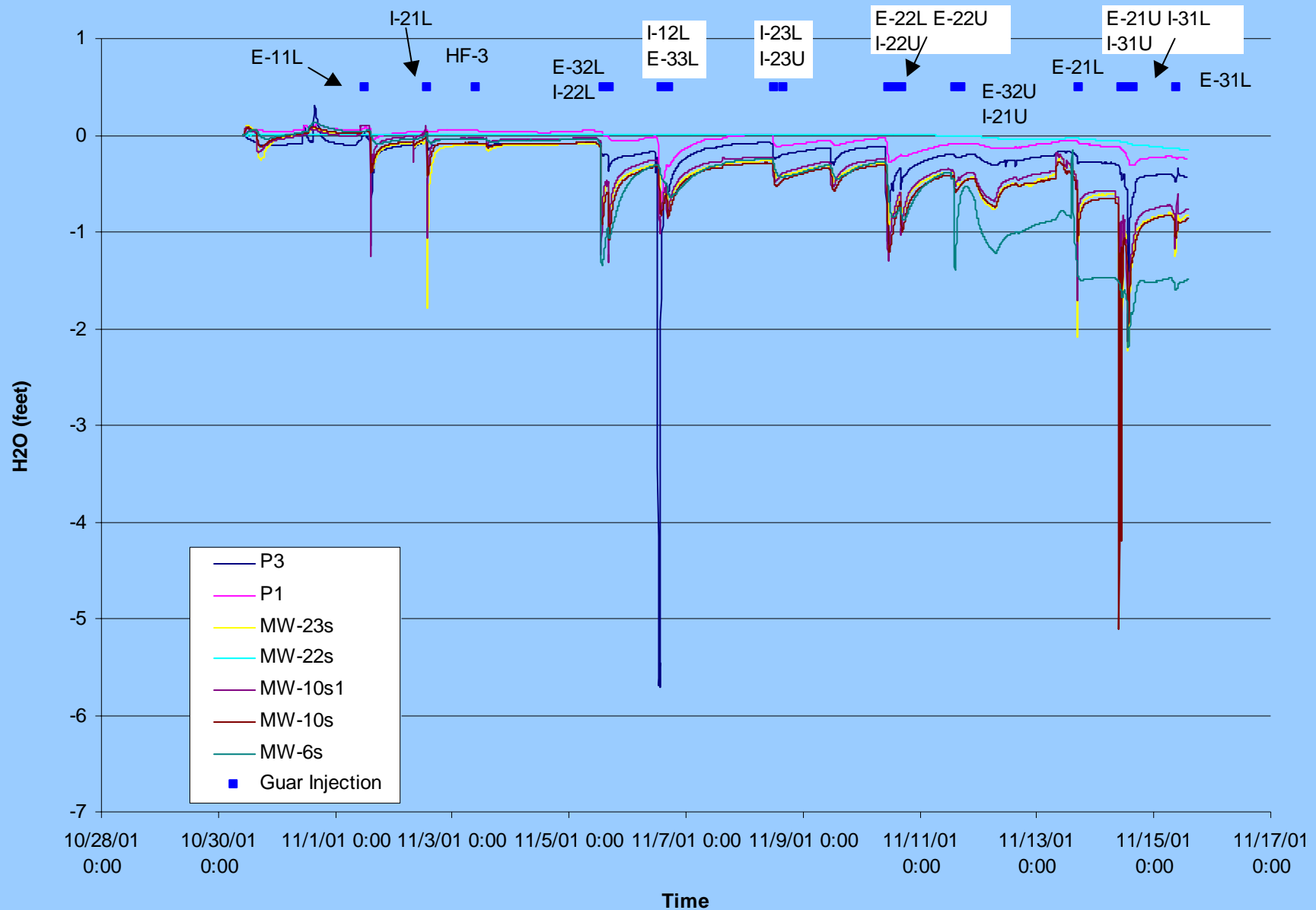
- Guar Gel
 - Organic powder thickener
 - Completely soluble in hot and cold water
- Sand
 - 20/50 mesh
- Borax
 - Used as an enzyme to break down the guar gel
24- to 48-hours after injection



Fractured wells



Water Level Response to Hydrofracturing



Full Scale Aquitard Hydrofracturing Conclusions

- 18 fractures were completed
- Did they result in horizontal or vertical fractures?
- How effective are the fractures?
- Will they stay open?
- Decided to connect only a subset of the wells to the existing treatment system, to evaluate the effectiveness of the hydrofracturing

Interim Aquitard Extraction System - Installed April 2002

Groundwater Extraction Rates 8/26 thru 10/17

Extraction Wells	gpm
E-22	0.37
E-33	0.15
E-03	0.20
E-32	0.15
E-21	0.41
E-11	0.56
Aquitard Average	0.31
Aquitard Total	1.84
Aquifer	10.76

Conclusions

- Hydrofractured wells averaged ~0.3 gpm
- Recovered approximately the same amount of contaminants from the Aquitard as we did from the Aquifer and Perched Zone
- The propagation patterns of the fractures is unclear